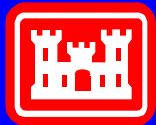


DoD Residential PEM Demonstration Program

Melissa K. White
Dr. Michael J. Binder
Franklin H. Holcomb
Nicholas M. Josefik
Scott Lux

United States Army Corps of Engineers
ERDC/CERL

2004 Fuel Cell Seminar
San Antonio, TX

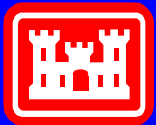


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Outline

- Introduction
- Approach
- Analysis
- Case Study – Prime and Standby Power
- Case Study – Critical Backup Power
- Conclusion

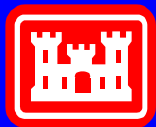


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Introduction - Background

- 83 PEM units at 42 sites
- Congressional funds made available:
 - FY04 ~\$ 2.4M
 - FY03 ~\$ 4.3M
 - FY02 ~\$ 3.4M
 - FY01 ~\$ 3.6M
- No Cost-Share Required



Introduction - Objectives

- Increasing DoD's capability at installations
- Assessing the role of PEMs in DoD's missions
- Providing operational testing and validation
- Assessing performance in a military base environment
- Stimulating growth in the industry.



Approach – Solicitation Requirements

- “Domestically Produced” PEM Units, 1 kW to 20 kW
- US Military Facilities/Embassies, etc.
- Turn-key Packages Requested
- Maximum Diversity Desired
- Minimum of 1 Year of “Fuel Cell Power” Required
 - At a minimum of 90% Availability



United Kingdom

New Zealand

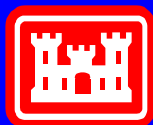
KEY: ● FY01 Site ★ FY02 Site ■ FY03 Site



Slide 6

FY01 Residential PEMFC Demonstration Projects

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
Brooks AFB, TX	Southwest Research Institute	03-Feb-03	15-Mar-04
Ft. Bragg, NC	LOGAN Energy	21-Nov-02	18-Feb-04
Ft. Jackson, SC	LOGAN Energy	05-Mar-03	04-Mar-04
Barksdale AFB, LA	LOGAN Energy	27-Feb-03	18-Feb-04
Ft. McPherson, GA	LOGAN Energy	30-Oct-03	N/A
Coast Guard Station, LA	LOGAN Energy	01-Nov-03	N/A
Patuxent River NAS, MD Office Building	Southern Maryland Electric Cooperative	14-Jan-04	N/A
Patuxent River NAS, MD Officer's Quarters	Southern Maryland Electric Cooperative	08-Jan-04	N/A
Geiger Field, WA	Avista Laboratories	06-Mar-02	06-Mar-03
Watervliet Arsenal, NY Research Facility	Plug Power	18-Jan-02	18-Jan-03
Watervliet Arsenal, NY Manufacturing Facility	Plug Power	18-Jan-02	18-Jan-03
Watervliet Arsenal, NY Officer's Quarters	Plug Power	15-Jan-02	15-Jan-03



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FY01 Residential PEMFC Demonstration Project Applications

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Brooks AFB, TX	Base Housing	Plug Power	Natural Gas	5	3	No
Ft. Bragg, NC	Office Building	Plug Power	Natural Gas	5	1	No
Ft. Jackson, SC	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Barksdale AFB, LA	Base Housing	Plug Power	Natural Gas	5	1	No
Ft. McPherson, GA	Base Housing	Plug Power	Natural Gas	5	1	Yes
Coast Guard Station, LA	Administration & Operations Building	Plug Power	Natural Gas	5	1	Yes
Patuxent River NAS, MD	Office Building	Plug Power	Propane	5	1	Yes
Patuxent River NAS, MD	Officer's Quarters	Plug Power	Natural Gas	5	1	Yes
Geiger Field, WA	Maintenance Fac.	Avista Labs	Hydrogen	3	1	No
Watervliet Arsenal, NY	Research Facility	Plug Power	Natural Gas	5	3	No
Watervliet Arsenal, NY	Manufacturing Fac.	Plug Power	Natural Gas	5	3	No
Watervliet Arsenal, NY	Officer's Quarters	Plug Power	Natural Gas	5	4	No



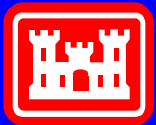
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FY01 PEM Fleet Performance Summary

January 15,2002 - July 31,2004

- Total Run Time 154,481 Hrs
- Average Availability 89.03%
- Capacity Factor 46.62%
- Total Electric Output 400,250 kWh
- Average Output 2.59 kW
- Electrical Efficiency
 - Natural Gas 24.27%
 - Hydrogen 27.25%
 - Propane 23.26%

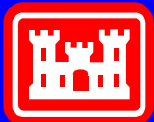


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FY02 Residential PEMFC Demonstration Projects

Site Name	Proposer	Fuel Cell Start-up	Demo End Date
ERDC/CERL, IL	LOGAN Energy	N/A	N/A
Fort Belvoir, VA	LOGAN Energy	N/A	N/A
Fort Belvoir, VA	LOGAN Energy	N/A	N/A
Fort Gordon, GA	LOGAN Energy	15-Mar-04	N/A
Georgia Institute of Technology ROTC, GA	LOGAN Energy	29-Feb-04	N/A
MCAS Cherry Point, NC	LOGAN Energy	N/A	N/A
McChord AFB, WA	Avista Labs	17-Apr-03	N/A
NCA&T University, NC	LOGAN Energy	24-Apr-03	N/A
Robins AFB, GA	LOGAN Energy	19-Jun-03	N/A
Saratoga Springs NSU, NY	Plug Power	29-Apr-03	N/A
Selfridge ANGB, MI	DTE Energy	26-Nov-03	N/A
Shaw AFB, SC	LOGAN Energy	1-May-03	N/A
Stennis Space Center, MS	LOGAN Energy	15-Feb-04	N/A
USCG Aids to Navigation Team, RI	Nuvera	12-Feb-04	N/A
West Point Military Academy, NY	Plug Power	2-May-03	N/A

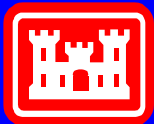


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FY02 Residential PEMFC Demonstration Project Applications

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
ERDC/CERL, IL	Research Facility	Plug Power	Propane	5	1	Yes
Fort Belvoir, VA	Undecided	Plug Power	Natural Gas	5	1	Yes
Fort Belvoir, VA	Undecided	Plug Power	Natural Gas	5	1	Yes
Fort Gordon, GA	Resource Center	Plug Power	Natural Gas	5	1	Yes
Georgia Institute of Technology ROTC, GA	ROTC Facility	Plug Power	Natural Gas	5	1	Yes
MCAS Cherry Point, NC	Maintenance Facility	Plug Power	Propane	5	1	Yes
McChord AFB, WA	FAA Radio Transmitter	Avista Labs	Hydrogen	3	1	No
NCA&T University, NC	ROTC Facility	Plug Power	Natural Gas	5	1	Yes
Robins AFB, GA	Fire Station	Plug Power	Natural Gas	5	1	Yes
Saratoga Springs NSU, NY	Base Housing	Plug Power	Natural Gas	5	8	Yes
Selfridge ANGB, MI	Fire Station	Plug Power	Natural Gas	5	2	Yes
Shaw AFB, SC	Base Housing	Plug Power	Natural Gas	5	1	Yes
Stennis Space Center, MS	Mars Habitat	Plug Power	Natural Gas	5	1	Yes
USCG Aids to Navigation Team, RI	Maintenance Facility	Nuvera	Natural Gas	3.7	2	No
West Point Military Academy, NY	Officer's Quarters	Plug Power	Natural Gas	5	3	Yes



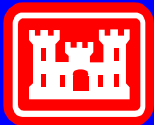
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FY02 PEM Fleet Performance Summary

April 17,2003 - May 31,2004

• Total Run Time	124,707 Hrs
• Average Availability	85.69%
• Capacity Factor	44.01%
• Total Electric Output	314,437 kWh
• Average Output	2.52 kW
• Electrical Efficiency	
Natural Gas	24.84%
Hydrogen	56.08%



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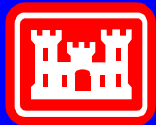
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West Point Military Academy Performance Summary

Base Housing (3 units)

May 02, 2003 - April 30, 2004

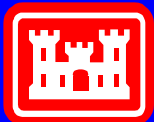
• Total Run Time	25,182 Hrs
• Average Availability	96.00%
• Capacity Factor	47.57%
• Total Electric Output	62,393 kWh
• Average Output	2.48 kW
• Electrical Efficiency	24.01%
• Thermal Efficiency	4.24%



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PEMFCs Installed at West Point Military Academy



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West Point Military Academy

Performance Summary

Site 1 – Base Housing, Boettner Residence

May 02, 2003 - April 30, 2004

- Total Run Time 8,451 Hrs**
- Average Availability 96.47%**
- Capacity Factor 48.04%**
- Total Electric Output 21,043 kWh**
- Average Output 2.49 kW**
- Electrical Efficiency 24.87%**
- Thermal Efficiency 4.92%**



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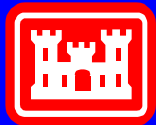
West Point Military Academy

Performance Summary

Site 2 – Base Housing, Nygren Residence

May 02, 2003 - April 30, 2004

• Total Run Time	8,204 Hrs
• Average Availability	93.91%
• Capacity Factor	45.84%
• Total Electric Output	20,021 kWh
• Average Output	2.44 kW
• Electrical Efficiency	22.41%
• Thermal Efficiency	1.25%



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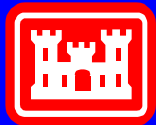
West Point Military Academy

Performance Summary

Site 3 – Base Housing, Massie Residence

May 02, 2003 - April 30, 2004

- Total Run Time 8,528 Hrs**
- Average Availability 97.62%**
- Capacity Factor 48.83%**
- Total Electric Output 21,330 kWh**
- Average Output 2.50 kW**
- Electrical Efficiency 24.82%**
- Thermal Efficiency 6.69%**



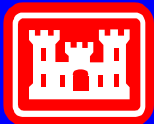
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PEMFCs Installed at McChord Air Force Base FAA Site



- 3 kW Total (six 500W systems)
- Radio Transmit Receive (RTR) Application
- Testing includes three simulated 20 minute outages/day



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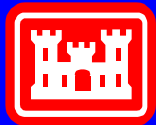
McChord Air Force Base

Performance Summary

FAA Radio Transmitter

April 17, 2003 – April 30, 2004

- **Total Run Time** 411 hrs
- **Start Ups/Attempts** 1102 / 1111
- **Availability** 97.7%
- **Capacity Factor** 3.2%
- **Total Electric Output** 834 kWh
- **Avg. Output for Site** 2.03 kW
- **Electrical Efficiency** 56.1%



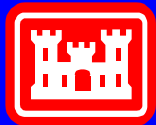
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McChord Air Force Base Hydrogen Fuel Summary

April 17, 2003 – April 30, 2004

- **Low Heat Value** 266.6 Btu/scf
- **Fuel Usage** 5,078,069 Btu
- **Fuel Usage** 18,844 scf
- **Average Fuel Usage** 45.9 scf/hr



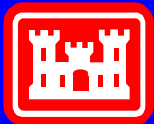
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DoD Residential PEM Project Fleet Performance Summary

January 15, 2002 - May 31, 2004

Program Performance Matrix								
Program Year	Total Run Hours	Availability (%)	Capacity Factor (%)	Total Energy Produced (kWe-hrs)	Average Output (kW)	Natural Gas Electrical Efficiency (%)	Hydrogen Electrical Efficiency (%)	Propane Electrical Efficiency (%)
FY01	148,533	89.0%	45.7%	377,006	2.54	23.6%	27.2%	24.1%
FY02	124,707	85.7%	44.0%	314,437	2.52	24.8%	56.1%	N/A
Program Totals & Averages	273,240	87.5%	44.9%	691,443	2.53	24.2%	29.0%	24.1%



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DoD Residential PEM Project Fleet Performance Summary

January 15, 2002 - May 31, 2004

- **Electrical Efficiency**

Natural Gas	24.18%
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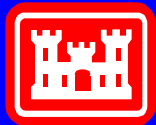
Hydrogen	28.97%
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Propane	24.12%
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- **Thermal Efficiency**

Natural Gas	6.48%
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Propane	21.58%
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DoD Residential PEM Project Fleet Performance Summary

January 15, 2002 - May 31, 2004

- **Scheduled Outages**

Number of Outages	65
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Total Duration	3,001 Hrs
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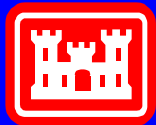
Mean Time	46.17 Hrs
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- **Unscheduled Outages**

Number of Outages	368
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Total Duration	21,432 Hrs
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Mean Time	58.24 Hrs
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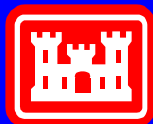


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FY03 Residential PEMFC Demonstration Projects

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Arizona Army National Guard, AZ	Army National Guard Armory	Plug Power	Natural Gas	5	1	Y
Montana Army National Guard, MT	Armed Forces Reserve Center	Plug Power	Natural Gas	5	1	Y
Ft. Benning, GA	Sandhill Recreation Center	Plug Power	Natural Gas	5	1	Y
US Army Sgt. Herrera Reserve Center, AZ	Herrera Army Reserve Center	Plug Power	Natural Gas	5	1	N
US Army Sgt. Herrera Reserve Center, AZ	Herrera Army Reserve Center	IdaTech	Natural Gas	5	1	N
Offutt Air Base, NE	Boiler Plant	IdaTech	Natural Gas	5	1	N
Offutt Air Base, NE	Communications Building	IdaTech	Propane	5	1	N
Ft. AP Hill, VA	Administrative Building	IdaTech	Propane	5	1	N
Sierra Army Depot, CA	Base Housing	Plug Power	Propane	5	1	Y
Keesler AFB, MS	Base Housing	Plug Power	Natural Gas	5	1	Y
Los Angeles AFB, CA	Security Center	Plug Power	Natural Gas	5	1	Y

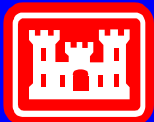


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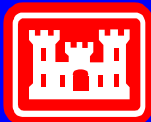
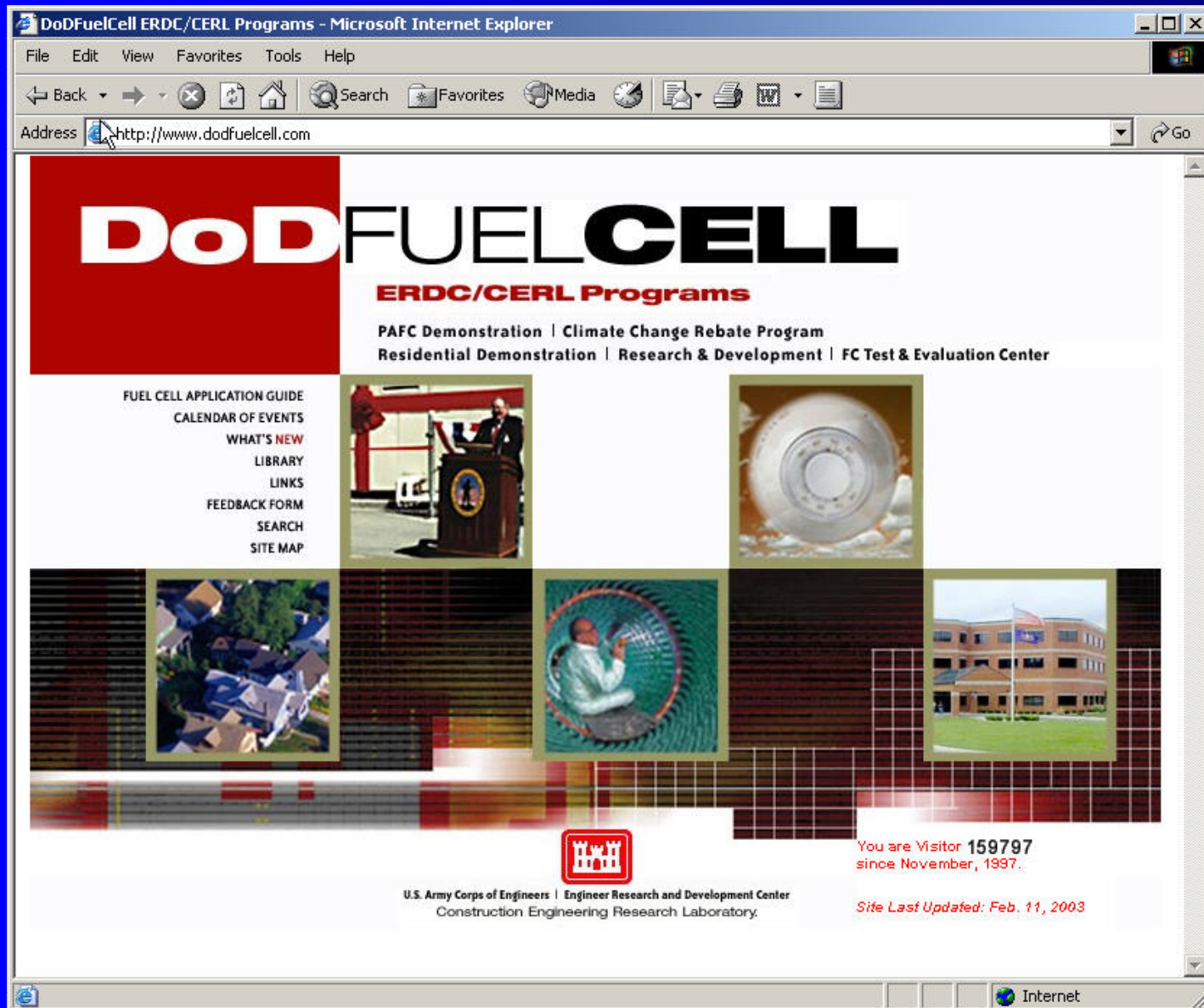
FY03 Residential PEMFC Demonstration Project Continued

Site Name	Building Application	Fuel Cell Manufacturer	Input Fuel	Size (kW)	No. Units	Cogen. Y/N
Hill AFB, UT	Base Housing	Plug Power	Natural Gas	5	1	Y
NGB Camp Mabry, TX	Base Housing	Plug Power	Natural Gas	5	1	Y
Schofield Barracks, HI	Clinic	Plug Power	LP Gas	5	1	Y
MCB Kaneohe Bay, HI	Base Housing	Plug Power	LP Gas	5	1	Y
March AFB, CA	Base Housing	Plug Power	Natural Gas	5	1	Y
McEntire ANG, SC	Security Center	Plug Power	Natural Gas	5	1	Y
U.S. Embassy, UK	Embassy Housing	Plug Power	Natural Gas	5	1	Y
Gabreski ANGB, NY	Telephone Exchange System	ReliOn, Inc.	Hydrogen	1	4	N
Fort Lewis, WA	Marker Beacon	ReliOn, Inc.	Hydrogen	1	4	N
Fort Rucker, AL	Marker Beacon	ReliOn, Inc.	Hydrogen	1	5	N
US Antarctic Div, Christchurch, N.Z.	Marine House	ReliOn, Inc.	Hydrogen	1	2	N



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